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APPLICATION OF THE W.I.R.A. FIBER LENGTH MEASURING MACHINE FOR WOOL

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SUMMARY

In this preliminary work the technique used was found to be quite satisfactory for measuring the length of individual wool fibers on the W.I.R.A. fiber length machine. The results were not decisive but certainly promising.

Results show the machine to be better suited to measuring wool fibers from card and top slivers than from grease wool staples. However, with additional preparatory work and with greater operator care the method can be adapted for measuring fibers from grease wool staples.

Analysis of the test data indicates that the agreement between the average fiber length of the grease staples (25 staples with 20 fiber measurements each) and of the card sliver (2 slivers with 100 fiber measurements each) was very good.

From the estimated within- and between-staple deviations a sampling schedule has been set up for use in determining average fiber length of any lot of wool by the W.I.R.A. fiber length machine.

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APPLICATION OF THE W.I.R.A. FIBER LENGTH MEASURING MACHINE FOR WOOL

BY H. D. RAY AND D. D. JOHNSTON 1/

INTRODUCTION

Fiber length information is a prime factor considered when placing a market value on wool. More detailed knowledge of fiber length and the variation of fiber length is rapidly becoming of greater importance to the textile industry. Changes and advancements in the spinning and manufacturing processes can be attained with maximum speed and efficiency only by having more scientific and detailed information about the fibers that are used.

For some years the Department of Agriculture and others have employed various sampling and measurement techniques in order to more accurately determine wool fiber length and variability in grease as well as processed wools (1), (2), (4), (5). 2/ The various methods devised have supplied valuable information, and favorable results have been obtained. However these results have not supplied the actual length measurement or variation in length between the individual wool fibers within a staple or within a lot of wool.

The purpose of this report was to investigate the application of the Wool Industries Research Associates 3/ fiber length machine for determining the length of individual wool fibers in grease wool staples, card sliver, and top (3).

MATERIALS AND METHODS

In this study samples of grease wool staples, card sliver, and top from a graded and unskirted lot of 3/8-blood wool were used. Fibers from each of the three samples were measured using the W.I.R.A. machine illustrated in figure 1.

To measure individual fibers, the operator of the W.I.R.A. machine grips each fiber at the end with pointed forceps and draws it under a wire which is held at a constant tension by means of a traverse screw. (See figure 1.)

1/ Wool Laboratory, Standardization Branch, Denver, Colorado

2/ Underscored numbers in parentheses refer to Literature Cited, page 10

3/ This fiber length measuring machine was developed by the Wool Industries Research Associates from which the name (W.I.R.A.) is derived. It is manufactured by A. Kershaw and Sons, Leeds, England.

As the extreme end of the fiber passes under the wire, the wire drops down making an electrical contact stopping the traverse screw and the movement of the fiber. A system of tabulating each fiber length in centimeter and half centimeter groups is provided on the machine. A fiber length tester similar in principle to the W.I.R.A. has been described by Wakelin and others (6).

For measuring fibers of the grease wool, 25 staples were drawn at random from the 120 staples originally drawn from the lot prior to scouring. These 25 staples were numbered and measured for unstretched length. The staples were then degreased by passing them through two solutions of carbon tetrachloride and, after drying, were opened gently by hand. Each staple was then combed lightly with a rather coarse comb at both the base and top to reduce breakage in the drawing process.

Preparatory to measuring, each staple was placed on a black velvet covered board which stood level with the traverse screw on the W.I.R.A. machine. A glass plate was placed on top of the staple so that only 1/4 inch of the base end of the staple protruded beyond the edge of the glass plate.

The fibers to be measured were carefully drawn at random from the base end of the staple.

In measuring the fiber length of the card sliver on the W.I.R.A. an undisturbed portion of sliver was selected at random from the samples provided. The sample was then placed on the velvet covered board with one end extending 6 to 8 inches beyond the edge of the board. A glass plate was placed across the sliver and back about an inch from the edge of the board. Small amounts were carefully pulled off, by hand, from the overhanging sliver until the sliver was squared off and extended not more than one half an inch beyond the edges of the glass plate. The operator proceeded with the measurement in the same manner as with fibers from cleaned grease staples, drawing fibers at random from all parts of the sliver across its width.

The wool top samples were measured by the same procedure described for the card sliver. One sample of card sliver and two samples of wool top were measured.

In addition to samples measured by the W.I.R.A. machine, as described above, an additional 120 staples of grease wool, from the same lot were measured for stretched and unstretched staple length (2), (4). The top samples were also measured with the Suter apparatus.

TESTING RESULTS

Table 1 gives two measurements, based on the W.I.R.A. results, for each of 25 grease wool staples. The first measurement is referred to as test

Figure 1.--W.I.R.A. fiber length machine

Table 1.--Average fiber length and variability of fibers drawn from grease wool staples and measured by the W.I.R.A. and unstretched length of staple from which fibers were drawn

Staple No.	Test No.	WIRA length	Difference between tests	Standard deviation	Coefficient of variation	Unstretched staple length	Difference between WIRA length and unstretched staple length
		Inches	Inches	Inches	Percent	Inches	Inches
1	1	3.46	2.50	2.04	58.86	3.00	+ .46
	2	0.96		0.39	40.82	3.00	-2.04
2	1	4.84	.33	1.13	23.41	3.50	+1.34
	2	4.51		1.93	42.79	3.50	+1.01
3	1	2.05	.45	1.44	70.38	2.00	+ .05
	2	2.50		1.13	45.35	2.00	+ .50
4	1	4.15	.77	2.11	50.80	3.25	+ .90
	2	4.92		1.85	37.52	3.25	+1.67
5	1	1.99	.47	2.01	39.80	2.50	- .51
	2	2.46		1.14	46.40	2.50	- .04
6	1	2.48	2.36	1.81	72.86	3.25	- .77
	2	4.84		1.31	26.99	3.25	+1.59
7	1	4.04	.27	1.22	30.34	2.50	+1.51
	2	4.31		0.92	21.46	2.50	+1.81
8	1	3.33	.95	0.87	26.27	1.75	+1.58
	2	2.38		1.58	66.45	1.75	+ .63
9	1	2.46	.20	1.60	65.00	3.25	- .79
	2	2.26		1.53	67.48	3.25	- .99
10	1	1.50	1.08	0.95	63.68	1.75	- .25
	2	2.58		1.79	69.31	1.75	+ .83
11	1	2.66	.44	1.31	49.48	3.25	- .59
	2	2.22		1.01	45.31	3.25	-1.03
12	1	3.54	.42	1.31	36.89	3.00	+ .54
	2	3.96		1.21	30.55	3.00	+ .96
13	1	2.07	1.43	1.51	73.14	2.25	- .18
	2	3.50		0.89	25.50	2.25	+1.25
14	1	1.75	.37	1.44	82.25	2.00	- .25
	2	2.12		1.43	67.41	2.00	+ .12
15	1	4.00	.02	0.98	24.63	3.25	+ .75
	2	3.98		1.07	26.83	3.25	+ .73
16	1	2.87	1.03	1.19	41.51	3.25	- .38
	2	3.90		1.02	26.06	3.25	+ .65
17	1	3.19	.57	1.30	40.74	3.25	- .06
	2	3.76		1.33	35.39	3.25	+ .51
18	1	3.05	.65	1.26	41.29	1.50	+1.55
	2	3.70		0.68	37.13	1.50	+2.20
19	1	2.16	.20	1.28	59.09	2.50	- .34
	2	2.36		1.42	60.00	2.50	- .14
20	1	2.46	.57	0.94	38.40	3.25	- .79
	2	3.03		1.81	59.74	3.25	- .22
21	1	2.60	1.48	1.88	72.58	2.75	- .15
	2	1.12		0.58	51.93	2.75	-1.63
22	1	4.98	.31	1.75	35.10	3.50	+1.23
	2	4.61		1.41	30.68	3.50	+1.11
23	1	2.64	1.28	1.86	70.44	2.75	- .11
	2	3.92		0.57	14.47	2.75	+1.17
24	1	2.29	1.88	1.94	84.82	4.00	-1.71
	2	4.17		1.75	41.89	4.00	+ .17
25	1	2.87	.53	1.83	63.56	2.75	+ .12
	2	3.40		1.53	44.86	2.75	+ .65
Average		3.10	0.82	1.36	47.55	2.80	+0.29

No. 1 and the second as test No. 2. Each test figure represents an average of the measurements of 10 fibers per staple. Also shown is the unstretched length of each grease wool staple from which fibers were drawn for the W.I.R.A. measurement.

Wide differences are shown between the first and second tests. The greatest difference (staple No. 1) was 2.50 inches. The smallest difference noted (staple No. 15) was 0.02 of an inch between the first and second tests. For all 25 staples, the average difference between the first and second tests is 0.82 inch.

Very little agreement was seen between the average fiber length as determined by the W.I.R.A. and the unstretched length of the staple from which the individual fibers were taken.

Twenty-nine of the tests with the W.I.R.A. gave a fiber length that averaged 0.95 inch longer than the unstretched length of the staple from which the fibers were drawn. Twenty-one of the tests gave a fiber length that averaged 0.62 inch shorter than the unstretched staple length.

As to the repeatability of tests 1 and 2, the table shows that in 16 cases, the two tests gave consistently longer or shorter fiber length measurements, as compared with the unstretched length of the staples from which the fibers tested were drawn. In 9 cases the two tests were inconsistent. Of the 16 cases in which tests 1 and 2 were consistent, 10 were cases in which the fiber length was longer than the staple length and 6 were cases in which the fiber length was shorter than the staple length.

The average unstretched length of the 25 staples used for grease wool measurements was 2.80 inches. The average length of fibers drawn from these 25 staples, as measured by the W.I.R.A., in tests 1 and 2, was 3.10 inches.

Table 2 shows that this average, 3.10 inches, compares very well with results of the two tests made with the W.I.R.A. on 100 fibers drawn from the card sliver. In tests 1 and 2 on the card sliver fibers, the average length was 3.09 inches.

Table 2 also reveals results of W.I.R.A. measurements on fibers drawn from wool top. These samples came from the same lot of wool as did those for the grease wool and card sliver fiber measurements.

Results of test 1 and 2 on 100 fibers drawn from top sliver No. 2 and on 100 fibers drawn from top sliver No. 4 were in close agreement except that test 1 on top sliver No. 4 gave a result .42 inch longer than the average of the other three tests on top.

Wool top fibers, as measured by the W.I.R.A., averaged longer than card sliver fibers. And W.I.R.A. measurements of wool top fibers averaged longer than the measurements of top fibers made on the Suter apparatus.

Table 2.--Grease staple, card sliver,and top sliver fiber length measurements as determined by the W.I.R.A.; average fiber length of wool top by the Suter apparatus, and unstretched and stretched average length of grease staples

	Length	Standard deviation	Coefficient of variation
	Inches	Inches	Percent
Fibers from grease staples - W.I.R.A.			
1st test (250 fibers), average	2.94	1.48	52.61
2nd test (250 fibers), average	3.26	1.25	42.49
1st and 2nd test (500 fibers), average	3.10	1.36	47.55
Card sliver - W.I.R.A.			
1st test (100 fibers), average	3.11	1.28	41.14
2nd test (100 fibers), average	3.07	1.26	41.02
1st and 2nd test (200 fibers), average	3.09	1.27	41.08
Top sliver - W.I.R.A.			
Sliver No. 2, 1st test (100 fibers), ave.	3.22	1.35	41.88
Sliver No. 2, 2nd test (100 fibers), ave.	3.12	1.44	46.08
Sliver No. 4, 1st test (100 fibers), ave.	3.62	1.24	34.13
Sliver No. 4, 2nd test (100 fibers), ave.	3.26	1.36	41.67
Tests 1 and 2, slivers 2 and 4 (400), ave.	3.31	1.35	40.94
Top sliver - Suter	2.96	1.15	38.85
Grease staples			
Unstretched (120 staples) average	2.72	0.58	21.32
Stretched (120 staples), average	3.51	0.72	20.51

The average unstretched length of 120 staples that were drawn from the lot prior to processing was 2.72 inches. This is shorter than the average results of either the first or second test on the grease staple fibers by the W.I.R.A. method.

It has been reported (3) that up to 500 fibers an hour can be measured on the W.I.R.A. However, it was found in measuring fibers from grease staples, 100 to 200 fibers per hour would be the maximum, depending on the type of wool and the condition of the staples.

VARIANCE IN FIBER LENGTH BETWEEN STAPLES, BETWEEN TESTS, AND WITHIN STAPLES

Analyses of the variation in average fiber length between staples, between tests, and within staples were made from the data presented in table 1. The results of these analyses are summarized in table 3.

Table 3.--Analysis of variance for fiber length

Source of variance	Sum of squares	Degrees of freedom	Mean square
Between staples	373.5090	24	1/15.5628
Between tests	12.9283	1	2/12.9283
Residual	1,142.0587	474	2.4094
	1,582.4960	499	

1/ Significant at the 0.1-percent probability level
2/ Significant at the 5-percent probability level

The differences existing in average fiber length between staples and between tests were statistically significant.

The sum of squares and degrees of freedom for between test and residual were pooled and from these the within staple mean square was calculated to be 2.4315.

On the basis of these data, the standard deviation value for between-staples was calculated to be 0.8102 inch and for within-staple 1.5593 inches.

Sampling Schedule For Measuring Length of Individual Fibers

From these estimated within- and between deviations, a sampling schedule for measuring the length of individual fibers was set up to show the number of staples to be selected at random from those drawn from a lot for the purpose of measuring unstretched staple length. The schedule set up in table 4 is for a precision of plus or minus 0.125 inch at a 95-percent confidence level.

Table 4.--Sampling schedule for a precision of plus or minus 0.125 inch at a 95-percent confidence level, based on a within-staple standard deviation of 1.5593 inches and a between-staple standard deviation of 0.8102 inch

Number of fibers tested per staple	Number of staples drawn from lot for measuring unstretched staple length					
	25	50	75	100	150	200
	Number of staples to be sampled					
5	1/ -	-	-	-	135	156
10	-	-	70	85	107	123
15	-	48	64	77	97	111
20	-	46	61	74	93	107
25	25	44	59	71	89	103
100	11	40	53	64	81	93

1/ No estimate; specified precision cannot be obtained with this number of fibers tested per staple.

The value of these analyses is not in the specific estimates calculated for between- and within-staple standard deviations nor the sampling schedule example, but in the general interpretations that can be made from these data toward future work of this nature.

Application of Sampling Schedule

The amount of work required is the first consideration in proposing a sampling and testing procedure for determining the average fiber length in a lot of raw wool. The amount of work is dependent on the precision with which the sampling and testing is to be done and the variation in staple and fiber lengths from a given lot of wool. Any relaxation of precision will cut down on sampling and testing work as well as the accuracy of the results obtained.

Probably the first indication as to how much testing is to be done is the number of staples that need to be drawn from a given lot of wool to work at the prescribed precision for the determination of unstretched staple length. A precision of 0.125 inch at the 95-percent probability level has been set up for this determination.

For example, if a lot had the same length variability as that observed in the wool of this study, approximately 100 staples should be measured to determine the unstretched grease wool staple length. For individual fiber testing, consulting the sampling data of table 4 it can be seen that, because of the variability in fiber length between and within staples, from 64 to 85 staples should be selected at random from the 100 staples. This is not too great a reduction from the 100 staples required for measuring the unstretched staple length.

Again consulting table 4, it can be seen that the number of staples that should be selected for individual fiber testing depends on the number of fibers tested per staple. Using the example, if 10 fibers were to be tested per staple, 85 staples should be used, thus making a total of 850 individual fiber tests. It can also be seen that as the number of fiber tests per staple is increased, the number of staples to be selected decreases. However, by increasing the fiber tests per staple and decreasing the number of staples tested, the total number of individual fibers to be tested increases. The table indicates that if 100 fibers were tested per staple, the desired precision would be attained by selecting 64 staples and making a total of 6400 individual fiber measurements. This is 7-1/2 times as many individual fiber tests as would be required if 10 fibers from 85 staples had been tested.

Therefore if it is not too time consuming to clean and prepare the individual staples for testing, it appears that it is more economical, in terms of labor involved, to test fewer fibers from more staples than it is to concentrate on a greater number of fibers from fewer staples.

Had the wool used in this study been more uniform, the amount of testing could have been reduced; however, if the testing is to be reduced, then the sampling precision will have to be relaxed and this decreases the confidence limits of the mean.

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